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EFFECTS OF SO_2 ON LICHEN PHYSIOLOGY

by

A.A. Khan, S.S. Malhotra, F. Radford
and P.A. Addison

Northern Forest Research Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

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ABSTRACT

Evernia mesomorpha Nyl. was fumigated with 0.34 ppm of SO_2 for up to 24 h at two frequencies of wetting. Both sets of lichens demonstrated measureable responses to the air pollutant but the magnitude of the response in lichens wetted more frequently (hourly) was several times greater than those wetted only once.

1. INTRODUCTION

Numerous studies of lichen distribution around industrial developments have demonstrated that lichens are susceptable to atmospheric pollution, particularly SO_2 (James 1973). In spite of this, no attempt has been made to relate biological impacts of industrial emissions on this sensitive taxon with long-term ecosystem effects. This is essential if the implication of industrial emissions is to be assessed. It is important to determine whether responses sensitive to industrial emissions in lichens can be related to those in vascular plants. This study was designed to determine various factors that influence lichen response to air pollutants. A comparison can then be made with known responses of vascular species and the effectiveness of lichens as biomonitors ascertained. Measurements at the biochemical and physiological levels have been used effectively to detect vascular plant responses to air pollutants and this approach to lichen response is directly comparable.

In 1980-81, efforts were concentrated in technique development related to environment and fumigation facilities using only SO_2 as an air pollutant. The aim of the study was to determine the effect of SO_2 fumigation and wetting frequency on lichen response.

2. MATERIALS AND METHODS

2.1 PLANT MATERIAL

Branches of jack pine (*Pinus banksiana* Lamb.) supporting a lichen community dominated by *Evernia mesomorpha* Nyl., *Usnea* spp, *Parmelia sulcata* Tayl. and *Hypogymnia physodes* (L.) W. Wats. were collected from a relatively pollution-free area near Fort MacKay in northeastern Alberta. Branches were collected air dry and stored in the laboratory in polyethylene bags at -15°C in the dark. The branches were brought to room temperature (20°C) but left dry before the experiment.

2.2 FUMIGATION CONDITIONS

Branches were divided into two groups, one to serve as a control and one to be treated with SO_2. Both groups were moistened by a fine mist of distilled water at the start of the experiments and mounted horizontally in the cuvettes. The cuvettes were placed in a controlled environment chamber at 20°C with a 16 h photoperiod and a photon flux density of 80 μMol $m^{-2}s^{-1}$. Humidified air (80-85% RH) was passed through the cuvettes at 10 ℓ $min.^{-1}$. Further details of the cuvettes are found in Malhotra and Khan (1978). Sulphur dioxide at 0.34 ppm measured with a Phillips PW 9700 SO_2 analyser, was provided for time periods of up to 24 h. The concentration was maintained by a feedback controller on a stepping motor-operated needle valve. The first treatment consisted of rewetting the lichens hourly for the first 16 h whereas in the second treatment the lichens were only wetted at the beginning of the experiment.

2.3 ANALYSIS OF RESPONSE

The phytosynthetic CO_2 fixation was measured by incubating 0.1 g of lichens in 3 ml of distilled water at 30°C for 10 min then further incubating the sample in the presence of $NaH^{14}CO_3$ (3.0 μCi)

at 150 μMol $m^{-2}s^{-1}$ photon flux density for 2 h. The reaction was stopped by adding 1 ml of formic acid 88% (v/v) and 16 ml of absolute ethanol. The contents were brought to a boil, cooled, and homogenized for 1 min with a Polytron homogenizer. The suspension was filtered through a Buchner funnel, and the residue was washed several times with hot 80% (v/v) ethanol. Aliquots of the filtrate were mixed with 0.1 ml formic acid in scintillation counting vials and flushed with a stream of N_2 on a hot-water bath to almost dryness. The residue was then dissolved in 0.1 ml distilled water and the fixed CO_2 was measured by counting $[^{14}C]$.

Protein biosynthesis in the lichen tissues was measured by the incorporation of $[U-^{14}C]$ leucine into proteins. This was done by incubating 0.1 g of tissue with 5 ml distilled water at 30°C for 10 min. After this initial incubation, $[U-^{14}C]$ leucine (1.5 μCi) was added to the solution, and the sample was further incubated for 4 h at 30°C with constant shaking under a 150 μMol $m^{-2}s^{-1}$ photon flux density. The tissue was separated by filtration and washed thoroughly with distilled water. The labeled tissue was then homogenized for 1 min in 10 ml of cold 0.1 M phosphate buffer (pH 7.0) using a Polytron homogenizer. Duplicate aliquots of each homogenate were mixed with trichloroacetic acid (final TCA concentration 10%) to precipitate proteins. The suspension was mixed and allowed to stand in ice for several hours. It was then centrifuged at 4°C and the residue was washed twice with cold 10% trichloroacetic acid and once with cold 80% (v/v) acetone. The washed residue was then suspended in 0.5 N NaOH and left for 10 min in a hot-water bath (60 to 70°C) to solubilize the proteins. The insoluble material was removed by centrifugation and an aliquot from the supernatant was assayed for $[^{14}C]$ incorporation into proteins. The $[^{14}C]$ was counted in a liquid scintillation system (Malhotra and Khan, 1978).

3. RESULTS AND DISCUSSION

Figure 1 showed that both protein synthesis (I) and photosynthetic $^{14}CO_2$-fixation (II) of *Evernia mesomorpha* were inhibited by 0.34 ppm SO_2 fumigation. The response was much greater in tissue that had been rewetted (set A) than in those which had only started moist (set B). During the initial period of fumigation both metabolic processes in each treatment were inhibited by SO_2 equally. Continued fumigation, however, resulted in drying of set B and a subsequent recovery whereas set A continued to respond. These results are of importance when attempting to understand the response under field conditions. It is expected that frequent wet periods during a pollution episode would be more deleterious to lichens than occassional wet periods followed by long dry ones. Much of the response is likely to be as a result of the longer period of time that the lichen can absorb SO_2 but the influence of the wetting and drying cycle warrents further investigation.

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SO_4 oxidizing in $H_2O \rightarrow H_2SO_4$,
other acidic compounds,
- Fort Mac - relatively moist
environ
- more sensitive lichen?
due to wet environ?

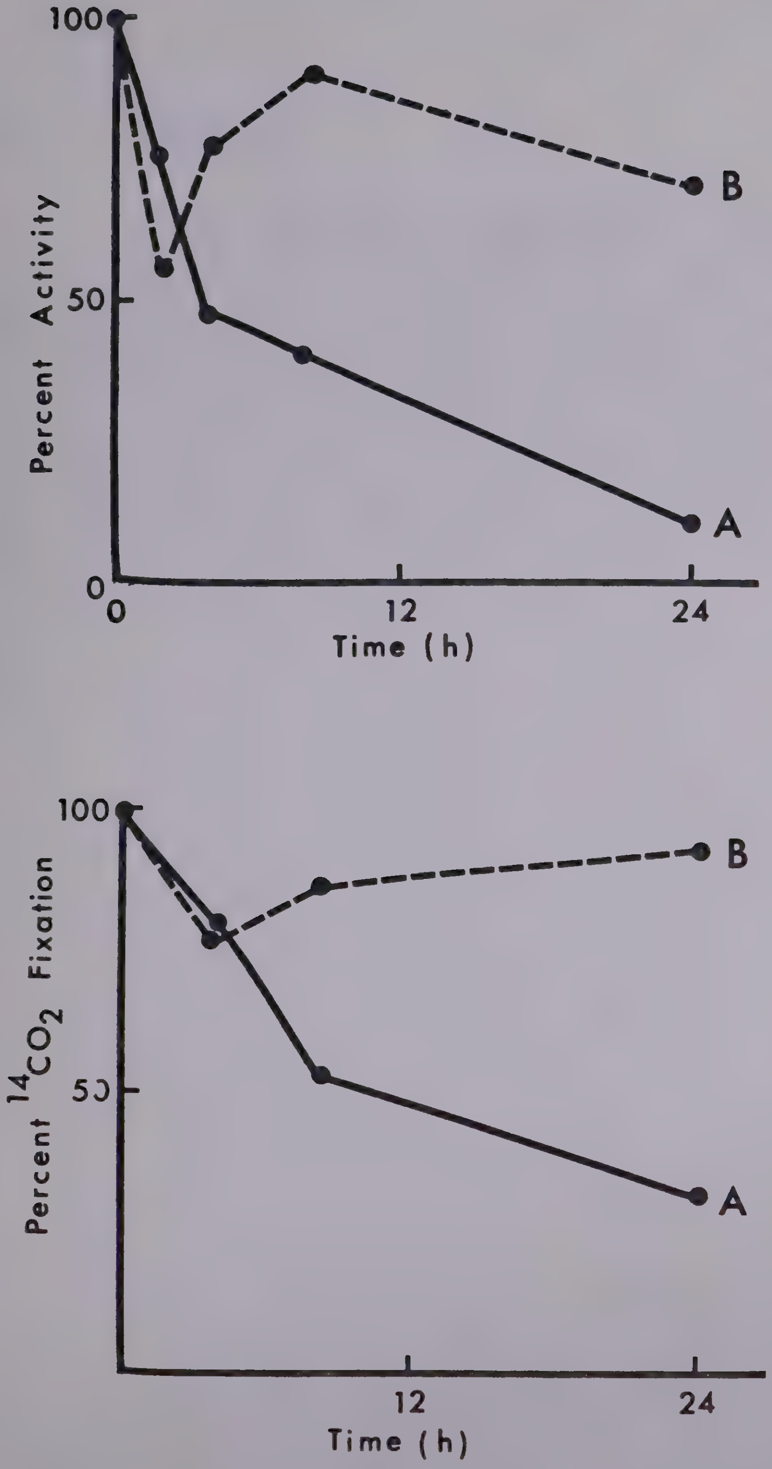

Figure 1. Response of protein synthesis (I) and $^{14}CO_2$ fixation (II) of *Evernia mesomorpha* during hourly wetting (A) and initial wetting only (B) while exposed to 0.34 ppm SO_2.

4. CONCLUSIONS

Much of the effort to date has been in the development of both the experimental facilities and the techniques to measure plant response. Initial results presented here indicated that environmental conditions can greatly influence the nature of lichen response to air pollutants. Long wet periods result in the lichen absorbing more SO_2 and hence, showing greater injury than under long dry periods. This type of response is not expected with vascular plants but the long-term implications of this finding is still unknown.

5. FUTURE WORK

A. Effect of sulphur uptake on lichen response .

B. Importance of wetting and drying on lichen response to SO_2.

C. The effect of SO_2 with NO_x on lichen metabolism .

D. Influence of environmental factors on lichen response to pollutants.

6. REFERENCES CITED

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